

HCI Design Principles for eReaders

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ABSTRACT

As interactive digital documents are becoming more and more commonplace, we find ourselves searching for new ways to make good use of them. The fast delivery and large storage capacity that digital devices offer, make reading from bulky physical books seem obsolete, even nonsensical. EReaders, the latest craze in digital reading, follows from the introduction of eInk and promises paper-like reading capabilities with the added digital benefits. But is the excitement justified? Can you ‘curl up’ with an eReader in the same way as you can a physical book, or is the design of eReading devices hindering this process?

As of yet, no one has taken a scientific view of current eReader technology from the systematic standpoint of basic HCI principles. This paper discusses guidelines for good eReader design and illustrates them with examples of shortcomings of some of the more popular eReader devices on the market today.

Categories and Subject Descriptors

H.5.2 [User Interfaces]: input devices and strategies; interaction styles; prototyping

General Terms

Design, Human Factors, Experimentation

Keywords

eReaders, eInk, Digital Documents, Evaluation

1. INTRODUCTION

Mass printing in the fifteenth century established what we know as the modern book, with its physical format of covers and paper pages, with now standard features such as page numbers. Reading is a complex human activity, that has evolved, and co-evolved, with technology over thousands of years. Reading has become a core part of human culture. To

the extent that new technologies conform to our cognitive, perceptual and cultural constraints, they will succeed. They may also free us from unnecessary constraints, and open new opportunities, introducing new ideas that will transform the culture of reading. As new technologies explore and push the boundaries, sometimes they will not be “quite right” and sometimes they will not go “far enough” — and some innovations will perhaps be very good for special purposes (even new purposes not previously envisaged) but not for reading in general. What are the tradeoffs for ease of use, and how do the leading reading technologies perform?

Although physical books are traditional, the written word is becoming more common in digital form, opening up a wide range of new reading possibilities. Despite the potential of digital texts, people are still reluctant to read from computer screens [9]. One possible reason for this preference is the eye strain caused by back-lit displays. This problem may be overcome by the introduction of eInk, which is illuminated, like print on paper, by reflected light.

EInk technology underpins current eReader developments, providing paper-like reading from lightweight digital devices. EReaders are both light and portable, and can store a vast amount of reading material that would be bulky and heavy in print. However, whether these new tools are a suitable substitute to traditional paper books, or whether they are best suited to slightly different purposes, remains to be seen. For example, somebody going on a long vacation may prefer being able to carry many books without weight penalties. On some vacations, the reliance of eReaders on battery power may be a problem, as well as the possibility of breaking the eReader if it is dropped. In contrast, conventional physical books rarely *fail*.

Traditional books are fixed, and can only serve one sort of use. For example, a large format book, which is easy to read for a user with vision defects, would be found large and unwieldy for a child with good vision. Most eReaders allow the size of text to be changed under user control, so the *same* book can be read by a user with high acuity or with vision defects needing large text. Some eReaders can generate a synthesized voice, so they are suitable for blind users. Similarly, dynamic search of the text for a word or phrase is a distinct advantage to digital books. However, printed books behave (broadly) consistently, whereas digital interaction allows for a greater variety and inconsistency. Furthermore, a digital book may become unreadable due to changes in standards or licensing.

Hence the design of the hardware and of the software within the devices is crucial to the overall reading experience

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of the user: how do eReaders support the tasks of readers? This is an HCI (human computer interaction) question.

This paper presents a discussion on the basic HCI design principles of eReaders. We examine the fine detail of good eReader design and reflect on guidelines appropriate for improved interaction. We illustrate our design guidelines for eReaders with a short review of three popular eReader devices:

- The Sony Pocket Edition (PRS-300): Small and portable. Designed concisely with reading in mind.
- The Sony Touch Edition (PRS-600): Touch screen interaction to aid in document mark-ups.
- The Amazon Kindle 2: Wi-fi enabled with full QWERTY keyboard for document mark-up and web browsing.

An Appendix provides brief technical overviews of these devices. The paper ends with a summary of the findings from our critique and a conclusion.

2. RELEVANT HCI ISSUES

Before we discuss what we learned from the example devices, we will first discuss key HCI principles associated with good eReader design. From these basic principles, we can assess the success of available eReaders and (as appropriate) suggest areas of improvement.

As an initial study, we have used heuristic evaluation [6, 7] to uncover usability concerns that are relevant to a cross-section of the most popular eReaders. The evaluation is also informed by the research literature on the HCI of reading (e.g. [1, 4]). Heuristic evaluation will not uncover all the usability issues with eReaders, but this initial study will uncover some systemic issues that can be readily addressed, and set a useful context for future work. What we focus on in this paper is how current eReaders might have different interaction designs that would improve their usability. We have applied the issues in this section to other devices, not reported in this paper, and they recurred in those other eReaders.

Note: for clarity, we refer to ‘users’ in the normal way and reserve the words ‘reader’ and ‘eReader’ to refer to the devices themselves. We do not pedantically keep referring to conventional books or physical books when the context is clear, but we do also use the term book to refer to the readable electronic content of eReaders, be it PDF or in some other format.

2.1 Metaphor

A metaphor is an expression that makes the comparison that something is like something else, and metaphors have been promoted as efficient ways of helping users understand interactive systems. Clearly, an eReader is like a book, and a book is therefore a metaphor for understanding eReaders. As books do not have buttons, the metaphor is only partial.

2.2 Lightweight

Marshall introduced the term ‘lightweight’ [5] for almost effortless activities, such as page turning, or putting a slip of paper into a book as a place marker. Clearly an important part of the success of eReaders is that sufficient lightweight reading activities in the physical world are successfully carried over into the eReader world and remain lightweight.

2.3 Ergonomics

The ergonomics of the device hardware is crucial for the overall success of an eReader. Making them thin and portable enough to hold in one hand is only a portion of what should be considered before manufacture. For example, which functions have dedicated buttons as opposed to on screen menus? And how easy is it to access these buttons from the main facia while holding the device as you would a book? Are frequently needed buttons or actions (e.g., for page turns) comfortable and flexible so the user is unlikely to get strain injuries? Are the buttons and actions re-assignable, so that the device caters for left and right handed people equally well? Are the displays legible, particularly for users with vision deficits?

2.4 Consistency

When designing a digital interface, thought should be given to the consistency of buttons and functions within it to ensure smooth user interaction with the tools. Poor consistency leads to bad interaction, and possibly low rates of use of the tools included in the system. It is vital therefore, that dedicated buttons should be well labeled and always perform the same function, such as: back buttons should *always* go back to the previous screen, zoom buttons should *always* zoom, and so on. Any variation in the functionality of these buttons could lead to confusion from the user.

2.5 Completeness

When reading a physical copy of a book, there are certain actions and affordances that are impossible to re-create on digital equivalents. For example, folding, ripping and flicking are just a sample of actions that are difficult to perform on an electronic reader device. Although there are certain things that cannot be replicated in this way, there are other actions and functions that could easily be incorporated into the software but are left out leaving us with a strong sense of incompleteness. For example, in physical books, when we insert a bookmark, we can usually see it along with any others entered, sticking out of the book while we are still reading. In digital eReaders however, bookmarked pages can only be seen while reading if they happen to be on the page you are reading. Otherwise, you must exit reading to view a list of all bookmarks within a book.

In a physical book, you can insert as many bookmarks as you please. In a sense, the bookmark process generalizes from a single example to being complete. In eReaders, there are often restrictions on bookmarks. Or an eReader may make the last page read an automatic, but special bookmark. This assumes that a user is only reading a book in one place at a time, as now the user has to distinguish between the last page they were reading and other pages they have bookmarked. For example, the page they are reading changes, but bookmarks do not. So looking up another bookmark loses the current reading location.

2.6 Reading Functions

EInk displays are slow to update, and combined with the simple microprocessors of readers, the number of steps a user takes to perform any task is more critical than on PCs, which have faster processors and faster displays. Thus, the features of a reader should be easily accessible, with minimal menu navigation, and short sequences of button presses.

Some eReaders have touch screens, but these are slow to

respond and tricky to manipulate because of screen update delays. Also, requiring a reader to hold a pen is “out of metaphor,” so more commonly used features should be or be complemented by dedicated physical buttons on the device’s facia. The features we will focus on in this paper are:

2.6.1 Bookmarking

Bookmarking in paper books is a lightweight [5] process; adding and removing physical placeholders can be so unself-conscious that users are unlikely to remember doing it. The equivalent tools on digital books are fraught with usability issues [3] and are consequently little used. How do eReaders accomplish such a well used feature within their documents? Do they provide dedicated buttons for this function? Can they be easily organized and deleted? How can the user view all the bookmarks in a single document?

2.6.2 Annotations

Reading is not always passive. When engrossed in a research project, many users will accompany reading with making notes; for example, highlighting, commenting and underlining [8]. This process is known as ‘active reading’ [2] and is a common activity for those who engage in knowledge-based tasks [1]. Annotations then, can be considered a by-product of the active reading process and can be easily achieved on paper documents using any of many lightweight methods. Assuming that eReader devices have catered for all reading audiences, as opposed to those who simply want to read a novel without making notes or placing bookmarks, how well do they incorporate active reading tools into their design?

2.6.3 Page Turning

Although page turning may seem trivial, how the device changes pages is a rather fundamental feature that if implemented incorrectly, would seriously hinder the reading process. When using the device for reading only, the most commonly used function will be the ‘Next’ button as it is used every time a user wants to change the page. The positioning of this next button, then, will be critical to the ease in which these devices are used. Placing the button in an awkward spot will cause un-natural hand movements which could be uncomfortable for users, and possibly lead to Repetitive Strain Injury (RSI).

2.6.4 Magnification

One feature that cannot be accomplished on paper without additional tools is magnification. This magnification or ‘zoom’ function should ideally allow visually impaired users to read from the same device and read the same books as those with perfect vision. One side problem with this feature, is how the devices restructure the document to fit on the screen when the zoom level has altered. Fundamentally, this is not an issue; the device will simply put more or less words on the screen than the original document presented. Looking deeper here however, we realize that this now alters what we know as page numbers; for example if the original document had 100 pages and the we zoom in to double magnification, it will now contain around 200 pages. What was page 1 will now be spread over page 1 and page 2. Clearly, this will now effect features such as bookmarks that rely on a page-referencing method of page numbers for relocation. How devices deal with this issue can effect users experience with reading as well as the features that are bound by it.

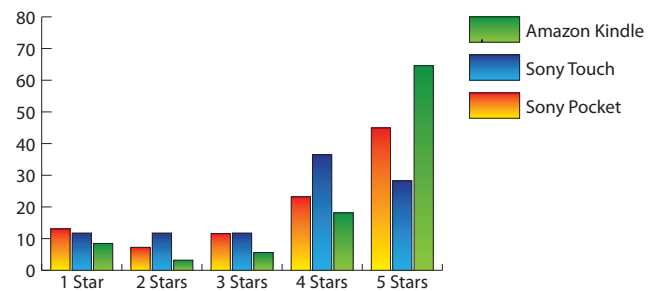


Figure 1: Graph showing the percentage of customer reviews giving each star level (source: Amazon.com).

Alternatively, a page can be zoomed to look larger, but not be reflowed. This retains the original page format and page numbering, but now requires the user to pan across pages to read them. (often this is the only option available for pictures.) It happens that the key design decision is typically forced by the format of the document being read: some documents cannot be reflowed, so most devices must provide both mechanisms.

2.7 Summary

In this section we identified some salient HCI principles that can frame a critique of current reader design. This was followed by a brief summary of some of the concerns that may arise in commonplace features of the reader software. We will now take a short glance at some readily available data on the user satisfaction reported with these devices.

3. USER DATA

Before we go into detail of our evaluation of our chosen example devices, is useful to consider consumer thoughts on the products. We looked to the ‘Customer Review’ section of Amazon.com for the 5 star Likert ratings given by buyers of the devices, gathered from the US Amazon site www.Amazon.com. Figure 1 shows the data we gathered.

The sample respondents of the Kindle is far greater than that of the Sony devices (some 15,000 for the Kindle versus less than 100 for both Sonys). We assume this is due to the exclusivity of the Kindle being sold on Amazon only, whereas the Sonys can be bought from many stores and online retailers, and therefore their users are less likely to provide assessments on Amazon.

It is clear from Figure 1 that the majority of users think highly of all three devices; giving scores of mostly 4s and 5s out of a 5 point Likert scale. However, the reviewers on Amazon are self-selected. If they had bad experiences they might tell the manufacturers, or if they simply gave up using the device they would probably wish to forget about it. On the other hand, excited users would likely be keen to tell everybody about their experiences. For an unbiased experiment, respondents need to be selected randomly or in some other controlled way, not self-selected. Nevertheless, what the Amazon data shows is that people who like eReaders really like them.

One might then ask, why the present paper if enough people already like the devices? HCI is about making things easier and nicer, and if enough people like something, isn’t



Figure 2: The eReaders reviewed in this paper: **LEFT:** Sony PRS-300 (pocket), **MIDDLE:** Sony PRS-600 (touch), and **RIGHT:** Amazon Kindle 2.

the HCI work finished? No. This simplistic view comes from commercial usability: if a manufacturer can stay in business selling profitable products to enough customers, then the business cost of further HCI research is questionable. In contrast, in research — where we place this paper — the issue is whether in principle a better user interface can be designed. In future, we would anticipate manufacturers using this research ‘for free’ and thus making better products.

4. DISCUSSION

We will now discuss the main findings from our evaluation of three popular eReader devices (shown in Figure 2). For clarity, technical details of the devices are summarized in the appendices. Appendix A provides brief technical descriptions of all devices considered here — form factor, battery, etc, and appendices B onwards provide critical reviews of specific models based on the HCI issues raised above in section 2. Considering the analyses of the various devices taken individually from the appendices, we now summarize the role of the various HCI principles for eReaders in general.


4.1 Ergonomics

The ergonomic design of eReaders strongly affects not only the ease of use of the functions, but in some cases, the comfort of the user while engaged with it, e.g. where commonly used buttons are positioned. The devices we evaluated have obviously been designed with aesthetics in mind, sometimes paying little attention to the position of such buttons. The Sony Touch for example, has opted for the minimalist design approach putting only 5 thin strip buttons on its fascia. Unfortunately however, the most commonly used button on the device (i.e. the ‘next’ button) has been placed second from the left in the row of buttons; an extremely awkward position for users to press while holding the device with one

hand (regardless of which hand they use). A similar position has been used in the Sony Pocket design.

In contrast to this, the Kindle has thought harder about their choice of button placement, choosing to place their two ‘next’ buttons on the sides of the device; perfect for clicking by the thumb of an individual holding the device in either hand. See sections B.1, C.1 and D.1 for details of how each of the three example systems deal with bookmarks.

4.2 Consistency

The consistency of the software within devices is certainly something that can be improved upon. We have touched upon several cases within our evaluation of the three examples in which the consistency of certain functions do not follow platform conventions. Examples of these range from button inconsistencies as in the case of the Sony Pocket’s Return  button (see section B.6), to function inconsistencies, like all the zoom function’s inability to increase the size of menus. Even the page numbers within several of these devices seem to be inconsistent (see 4.4), recalculating page numbers at every zoom level undermines the traditional connection between a word or sentence and a particular page (or location) identifier, and complicates the interaction for functions that are dependent upon them; e.g. bookmarks.

4.3 Completeness

As we have discussed earlier in the paper, digital devices that mimic physical ones have certain expectations that are not always fulfilled; consequently the sense of completeness within devices such as these, are rare. For example, in a paper book it is possible, that in certain situations you would want to add more than one bookmark to a page; perhaps in the form of Post-its to mark interesting parts on the top and bottom sections. This function however, is impossible

on all three of the devices we sampled; in all three readers, a page could either be bookmarked or not bookmarked with no facility to add additional ones.

Another example of this would be flicking through a document: a process that is easy to accomplish on paper and useful for quick navigation. Achieving this interaction on eReaders though is far more cumbersome. Of the readers we reviewed, the two Sony models had no tool for such interaction. The Pocket Edition (PRS-300) did include dedicated number buttons for navigation to specific page numbers, but neither allowed for free flicking through pages within the document. In contrast, the Kindle made use of its 5-way directional stick to allow for quick flicking through pages. Unfortunately the screen update speed of the Kindle is slow, and so it is difficult to see how quickly you are moving from page to page.

4.4 Page Numbers

The slow refresh speed of eInk technology means that eInk-based reading devices use pagination rather than scrolling. The use of pagination is therefore a critical issue within the use of eReaders, as it is the only viable navigational method. Whereas paper documents inextricably connect the physical page and page numbers, digital texts are free from that constraint, and may be re-formatted, completely altering the numbering system. Besides the obvious problem of referencing physical books to their digital equivalents, this system gives a lot more freedom than paginated documents can offer. Why then are we still using paper-like ideas like bookmarks in our digital reading design?

The page numbering on the PRS-300 for example, follows suit with most Sony eReaders. The device does not seem to keep the page numbers of the original document unless they are encoded into the document itself. If they are well-made PDFs with specific page numbers then the pages stay constant throughout: if you zoom in then the device does not reorder the pages, it simply splits each page into smaller pages and names them accordingly. For example, if an original document was 10 pages and we zoom to 4x magnification, page 1 would now span over 4 pages; all of which would be called Page 1. This method of page numbering is useful if users are co-ordinating with physical copies of the same book (e.g. in a reading group). It can be confusing however, to have multiple pages with the same page number. A more suitable solution to this problem when on a larger zoom level would be to keep the original page numbers but also include how many of them they are, as in “Page X (Part Y of Z)”.

The other, more common page numbering system used by Sonys eReaders is to calculate the number of pages within a document on the fly depending upon the zoom level. Thus the more zoomed in you are, the more pages there are in the book. This method however, now leads into further problems, such as the shared reference problem encountered by those collaborating using the same document [4]. Previously, when two users were reading separate copies of the same document, they could say “hey look at page X, paragraph Y”. Now to find the particular passage a user would also have to say “go to zoom level S then go to page X paragraph Y”.

Another problem faced here is bookmarking. If a user places a bookmark on a page then zooms in, the old bookmark is ‘lost’ as only one of the multiple pages the original page now spans over is left bookmarked by the system. For

example, if I were to bookmark page 10 on the smallest zoom level then zoom in to 4-times magnification, my original page 10 now spans over 4 pages, except the system only bookmarks one of these 4 pages. Similarly, if a bookmark is made when the document is on a high zoom level, then it is zoomed out again, the bookmarked page is now far bigger than it originally was; how then, will the user know exactly which part they intended on bookmarking?

What the system seems to do here is take the first line on the page being bookmarked and take that as the anchor point for the bookmark, ignoring any other text on the page. Thus whatever page the first word of the original bookmarked page is now on, is the only one which gets a bookmark on the new zoom level.

In contrast to the Sony Models, the Kindle 2 has opted to do-away with conventional page number format and replaces them with ‘locations’ that correspond to specific places within the text. Instead of page numbers then, which are in fact, rather useless in the digital world as they are not ‘pages’ as such, the Kindle measures the file in locations that are linked to specific positions of text within the document. Each location always corresponds to the same position in the text no matter now the text is being split for the display; i.e. how big or small the font is. This means that one screen can contain more than one location depending upon the zoom level and where the text breaks.

Despite this location system however, the device still seems to have trouble with bookmarks. As with the Sony’s, the Kindle 2 also takes the first word of the originally bookmarked page to be the anchor for the bookmark and ignores any text thereafter. This means of course, that if the interesting part of the page you bookmarked happened to be at the bottom, you would lose its place if you changed to a different zoom setting.

Both the Sony’s and the Kindle fall into the electronic bookmark trap; first forcing bookmarks to reference ‘pages’ and then not reformatting them when the arrangement of the pages change. A major improvement to these devices then, would include a ‘bookmark’ system that as far as the user is concerned, bookmarks pages, but underneath actually references specific positions within the text. The Kindle’s location system is well equipped for this system already, yet fails to utilize it in a useful manner. When a ‘page’ is bookmarked, despite the zoom level, each and every part of the text within that ‘page’ should be tagged as being bookmarked. It is these tags that should then be used when the document is resized to calculate which pages should be bookmarked. This would solve the problem of only one out of many zoomed pages to be bookmarked after a reformat to a higher zoom level.

We now turn to the reading functions listed in Section 2.6 and discuss in turn the usability concerns with each of the tools that a user may commonly use in their use of a reader.

4.5 Bookmarks

As we have just discussed, the problem of so called ‘page numbers’ within digital texts can significantly affect what we know as bookmarks. This is not the only problem that eReader bookmarks can suffer from however.

Despite bookmarks being a well-used function in physical books, many eReader designs do not incorporate a dedicated bookmark button into their facia design. Instead forcing internal menus to be used. Furthermore, in all three of the

devices we evaluated, viewing a list of bookmarks cannot be done whilst reading a book; rather, the user must navigate out of the document and into a menu to retrieve the bookmark list. See sections B.2, C.2 and D.2 for details of how each of the three example systems deal with bookmarks.

4.6 Annotation

Active reading [2] is a very common activity and describes not only reading, but also the process of thinking and marking-up documents by annotating, highlighting, extracting information etc. On paper these actions are easily performed and can be considered to be ‘lightweight’ [5] as the user actions can be “so unselfconscious, they are not apt to remember them later”.

It is clear then, that in order to facilitate active reading in the same way as paper, adequate mark-up tools need to be included into eReader designs. Sadly however, of the three we sampled, only one (Sony Touch PRS-600) had the touch-screen facility to create hand drawn notes, while the Kindle made do with highlights and hidden typed notes. The Sony Pocket PRS-300 had no annotation facility whatsoever; making the device useless for active reading and rendering it somewhat incomplete (see section 2.5). See sections B.3, C.3 and D.3 for details of how each of the three example systems deal with annotations and marks.

4.7 Magnification

With the exception of the Sony Touch Edition that does offer an additional zoom and pan function (for within documents only), magnification on the devices actually involves reformatting the text of the documents by increasing or decreasing the font size. This is a useful feature particularly for those with vision impairments. Unfortunately however, the consistency of the magnification of these devices is inconsistent and does not extend to the menus, rendering the device relatively useless for those with poor vision unless a third party performs all the device navigation. See sections B.5, C.5 and D.5 for details of how each of the three example systems deal with magnification.

4.8 Improvements

There are several areas of eReader design that could be significantly improved by paying attention to the basic HCI principles outlined in this paper. Firstly, the button choice and placement on the devices facia should be carefully considered. Commonly used functions such as next and bookmarks should have their own dedicated buttons and should be placed conveniently to avoid discomfort during long reading sessions. As we discuss in the Appendix, the ‘next’ buttons on the Kindle are perfectly positioned to coincide with the thumb positions of users holding the device in their left or right hand.

Further to button positioning, device manufacturers must also ensure that the buttons and functions within the device are consistent. Users should not have to wonder what action the button or function will perform every time they use it; it should consistently perform the same action. Designers should also strive for completeness: ensuring that tools and actions within the device mimic the actions that can be performed on paper, unless this is demonstrably inefficient in a digital interaction. In doing so, the functions within the device will become more ‘lightweight’ and improve the interaction between the user and device.

There are certain principle conventions that should be followed in order to ensure good user interaction with the tools. For example, due to the technology used, the screen update speed is slow on these devices. Therefore, an obvious remedy to this problem would be to reduce the number of screen updates. Sadly in the examples we chose there were several instances where the devices failed to do this. In the Sony Touch for example, the main menu screen is not one big list; you must scroll down after several entries to view the second half despite there being ample room for the entire list on the screen at one time. This causes unnecessary button clicks and page refreshes that could easily be avoided if the menu was contained in a single list.

4.9 eDocuments

Bearing in mind predictions of a paperless office [11], it might be useful to consider the heart of the operation; digital versions of traditional reading material, also known as eDocuments. There are many formats of electronic document (eg PDF, BBEB, EPUB), most of which can be used on the eReaders we have critiqued in this paper.

One of the major concerns users seem to have with the eDocument paradigm, is the fact that they do not actually own a physical copy of the book. In previous studies we have conducted [3, 10] on this topic, we discovered that many users feel almost cheated by buying an electronic document, coming up with comments like “I’d rather have the [physical] book because it looks good on my shelf”.

Another issue with electronic documents is the price. Often, if you go to a book store you can buy a physical book on sale for only a few dollars or benefit from a buy one get one free offer. However, if you head to Amazon to buy an eBook they are, more often than not, full price making them more expensive than buying a physical copy. The overheads of electronic books are practically nothing; no printing, material or delivery costs are incurred, yet these savings are not passed on to the consumer. In fact in many cases they are trying to charge more for an electronic copy.

Further to this, what happens if you already own a physical copy of a book but now want to read it on your eReader? The answer is, you must buy another copy. When you buy a CD you can listen to it in your car or on your stereo and you can also rip a copy onto your computer so you can listen to it on your MP3 player. The popularity of portable music devices like MP3 players would be no where near as high if consumers had to rebuy all their music in digital format as opposed to simply copying it from CDs. So why are books so different? Why can’t physical books come with a memory device containing an electronic copy attached? Or, if an electronic copy is all that is required, should they not be cheaper than their physical counterparts considering how cheap they are to produce?

These issues, if left unresolved, could seriously hinder the success of devices such as eReaders. Although the current digital reading consumer market is, at present, content with simply being able to store and read hundreds of books on one device, they will not ignore these issues forever.

5. CONCLUSIONS

This paper has explored the basic principles and issues associated with eReader design and backs them up with real world examples from three popular electronic reading devices. Our paper has used HCI principles to *think* about design. This provides a much wider range of insights than what

has become the ‘conventional’ mode of HCI which is based on empirical experiments. Here, empirical experiments can only answer one question at a time (unless they are carefully designed), and then the data itself does not provide insights into design rationale. Hence this paper was based on an exploration of *principles* — a variant of expert heuristic evaluation.

It is clear from our investigations that these devices leave a lot to be desired, at least from an HCI perspective if not from a business/usability perspective. Many of them have focused too strongly on the aesthetics of the hardware design to ensure they have included a visually pleasing symmetrical pattern on the facia.

Of the three devices we inspected, we feel the Kindle 2 has matched our criteria better than the others. Its ergonomic design makes it easier to hold and, more importantly, turn pages. It caters to users independent of their left/right handedness. Despite it lacking a touch screen interface, the Kindle still manages to facilitate active reading [2] by incorporating a full QWERTY keyboard into its design, which aids with annotations and web browsing. We were also impressed with its location method of page positioning, even though (in our opinion) it could have been put to better use. Obviously the Kindle is not a perfect example of what an eReader could be, but by paying close attention to the principles and guidelines laid down here it could be largely improved — as could any such device.

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

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APPENDICES

A. TECHNICAL SPECIFICATIONS

A.1 Sony Reader Pocket (PRS-300)

Display: 5 inch eInk (8-Level Greyscale)

Physical Buttons/Devices: Power Switch,  (Home),  (Return),  (Previous Page),  (Next Page),  (Next Page & Move Cursor),  (Previous Page & Move Cursor), <blank> (Enter),  (Bookmark),  (Size), Number Buttons X 10

Resolution: 800 x 600 pixels

Size: 159 x 108 x 10mm

Weight: 220g

Wireless Connectivity: None

Memory: 512MB Internal

Expansion: None





Power: Sealed Internal Lithium Ion Battery - around 6800 page turns on one charge

eBook Formats Supported: Adobe PDF, TXT, RTF, Microsoft Word, BBeB, EPUB

RRP: £199.99

A.2 Sony Reader Touch (PRS-600)

Display: 6 inch Touch Screen eInk (8-Level Greyscale)

Physical Buttons/Devices: Power Switch, Vol -, Vol +,  (Previous),  (Next),  (Home),  (Size), Options

Resolution: 800 x 600 pixels

Size: 175 x 122 x 10 mm

Weight: 286g

Wireless Connectivity: None

Memory: 512MB Internal

Expansion: Accepts Memory Stick Pro Duo (MS) and Secure Digital (SD) cards up to 16GB

Power: Sealed Internal Lithium Ion Battery - around 7500 page turns on one charge



eBook Formats Supported: Adobe PDF, TXT, RTF, Microsoft Word, BBeB, EPUB

RRP: £279.99

A.3 Amazon Kindle 2

Display: 6 inch eInk (16-Level Greyscale)

Physical Buttons/Devices: Power Switch, Vol -, Vol +, PREV PAGE, NEXT PAGE X 2, HOME, MENU, BACK,

Full QWERTY Keyboard,  (Symbol),  (Text Size), 5-way Directional Controller

Resolution: 800 x 600 pixels

Size: 203 x 135 x 9 mm

Weight: 289g

Wireless Connectivity: 3G

Memory: 2GB Internal

Expansion: None

Power: Sealed Internal Lithium Polymer Battery - up to one week (with wireless on) on one charge





eBook Formats Supported: Kindle (AZW), TXT, ADOBE PDF, HTML, MS WORD, JPEG, GIF, PNG

RRP: \$189.99

B. SONY READER POCKET (PRS-300)

B.1 Ergonomics




PRS-300

The Sony Pocket edition has several sets of buttons on its main facia. As well as its home  and return  buttons, the device also includes dedicated buttons for bookmarks  and font size  as well as a circular directional pad and enter button and a set of 10 numerical inputs. These buttons have been arranged in a somewhat symmetrical pattern forcing the directional inputs (used for next and previous functions) to be placed in the middle of the device below the display screen. This is not the best place to position a feature as commonly used as the next button as it can only be easily accessed by the thumb of a left or right hand if the device is being held by the bottom edge.

For quick navigation to menu options or page numbers, the PRS-300 has 10 numeric buttons down its right hand side. Unusually however, these 10 buttons have been combined into 5 sets of 2 that resemble on/off switches.

B.2 Bookmarks

PRS-300

The PRS-300 model has a dedicated bookmark button . Clicking on this button within a document will cause a 'dog ear' to appear in the top right hand corner, indicating that the page has been bookmarked. Clicking the button on an already bookmarked page deletes the current bookmark. This 'dog ear' visualization however, does not give an overview of which pages are bookmarked, as only the currently open page can be seen on screen. To view a list of all bookmarked pages, the user has one of two choices. The first option, that can be accessed through the main menu  (button) –  **All Bookmarks (on screen menu)**, lists all bookmarks in all books stored on the device in one big list. The second and possibly more useful option, is to view only the bookmarks within a single book. This function however, must be accessed from the **Options** menu for that particular document which is not an easy menu to locate.






B.3 Annotations

PRS-300

There are no facilities to create annotations, notes or highlights on the PRS-300. The manual confirms that these functions can be used within the eBook library on a paired PC, but the device would be unable to open or use them.

B.4 Page Turning


PRS-300

Page turning  on the PRS-300 is accomplished by using the circular directional pad below the main screen;  and  for Next and  and  for Previous. Assuming the device will be held in one hand for reading, the position of this

directional pad is just about in range of the thumb of a right handed individual holding it on the bottom half. Left handed users however, may find it a strain to stretch their thumb to the next button after several page turns.

B.5 Magnification

PRS-300

Although there does not seem to be a zoom mode within the device, there is a size  button that toggles between three different font sizes. This button, however, does not change the font size of the home or options menus, which are a constant size throughout.



Despite the device giving visual feedback to state the zoom is not possible on the menu, it is an inconsistency that could hinder visually impaired users.

B.6 Inconsistencies

PRS-300

B.6.1 Document Options

PRS-300

The device offers a specific menu for the options of a document that provides functions for utilities such as document info, table of contents etc. As there is no dedicated options button, the user has one of two choices to access the menu. Firstly, selecting a document from a list (either by title, author or date) on the device will automatically show the options for that document before allowing reading to commence. The second option which can be accessed from within a currently open book, requires the user to click the return  button to access the options screen. Obviously, this button is not labeled as an options function and does not always behave in the way you would expect: i.e. return the user to the screen they were on prior to the current screen. Under normal circumstances (e.g. if you are in the Date and Time menu) clicking return , takes you back to the previous screen: (e.g. the main Settings page). However, in some instances it behaves as a menu button: e.g. if you were on page 5, and then use the number buttons to take you to page 55, the return button *should* take you back to page 5. Similarly, if you were on the home screen then continue reading, the return button *should* take you back to the home screen again. However, in these two examples, the return button actually takes the user to the options screen for a book instead of returning them to the previous screen.


C. SONY READER TOUCH (PRS-600)

C.1 Ergonomics

PRS-600

C.1.1 Buttons

PRS-600

With the added benefit of a touch screen, Sony has been able to make the screen the main focus of the device by limiting the number of physical buttons on its facia. They have opted to place 5 thin buttons on the device and place the icons of their functionality just above them effectively reducing their target boundary. The positioning of these buttons however has not been thoroughly thought out and looks strikingly similar to the layout you would expect to find on a digital music player. The page turning  buttons (<) and (>) for example, have been placed adjacent to each other on the left hand side of the device. This puts the most commonly used function, i.e. the next page button (>), in an extremely awkward position; one that would not suit the thumb or finger position of a left or right handed individual.



C.1.2 The Display



PRS-600

One of the main selling points of eInk hardware is the absence of a back-lit display making it more comparable to ink on physical paper documents. This technology not only saves battery power, but also to facilitates traditional paper reading practices that are more difficult to accomplish on illuminated digital devices, e.g. no backlighting reads better in direct sunlight. Unfortunately, the Touch Edition Sony Reader has undermines this feature due to a translucent top layer that is responsible for the touch screen functions of the device. This additional layer is partially reflective and therefore picks up ambient light in the room making the device more difficult to read and feel less like a real book.

C.2 Bookmarks


PRS-600

There are two methods of creating a bookmarks on the PRS-600, but unfortunately, both demonstrate poor user interaction. The bookmark feature is classed by the device as a 'Note' and therefore exists within the Notes menu: **Options (button)** –  **Create/Edit Notes (on screen menu)** –  **(on screen icon)**. This seems like a rather long-winded method of performing a simple operation like bookmarking; a task that is so easily accomplished on paper. To get around this, the device has a short-cut bookmark option that requires double tapping in the top right corner. However, this feature is not supported by any kind of visual cue and therefore can only be discovered by close reading of the full user manual (not included) or by random discovery.

To indicate to the user which pages are bookmarked, the device displays a small triangular 'dog ear' in the top right corner the display which can be seen only when a bookmarked page is open. To view a list of all bookmarks within a document, the user must navigate through a series of menus: **Options (button)** –  **Create/Edit Notes (on screen menu)** –  **Notes (on screen menu)**. The 'Notes' menu is an ordered list of all annotations associated with a particular document; specifically, it merges every user created mark-up within a specific document into the same list, i.e. bookmarks, highlights, handwriting and comments. Each of these different annotation types are distinguished in the list by a different icon, and the lists can be ordered by page number, type or comment. One major flaw of this type of list based interaction however, is the lack of overview of where bookmarks exist in the document. In paper books relative placement of bookmarks can be easily seen as well as how much has been read/left to read etc.

C.3 Annotations



PRS-600

The Touch edition Sony reader contains a within-document 'notes' system that can be accessed via a series of menus, specifically: **Options (button)** –  **Create/Edit Notes (on screen menu)**. This then scales the document view very slightly to provide a small, clear space for the notes menu that sits along the top of the viewing window. Within this menu, users can either; add highlights to the book content, access free-hand mode using the stylus, delete using the eraser, add/remove bookmarks and access the notes list. In reality, notes and bookmarks are different things to the majority of users. It seems odd never mind long winded then, that Sony has decided to combine them into a single entity and effectively bury one within the other. The following subsections describe the functions that Sony has

grouped under the common name 'Notes'.



C.3.1 Highlights

PRS-600

Existing text within the open document can be highlighted by first accessing the highlighter function hidden within the Notes menu: **Options (button)** –  **Create/Edit Notes (on screen menu)** –  **(on screen icon)**. They can be removed by using the eraser tool also found within the Notes menu. As mentioned above, once a highlight has been created it is automatically added to the Notes list along with other types of annotations in the document.

C.3.2 Handwriting

PRS-600

The device makes good use of its touch screen technology by incorporating a handwriting function into its design. By accessing the same Notes menu as other document annotation tools (**Options (button)** –  **Create/Edit Notes (on screen menu)** –  **(on screen icon)**), users can 'draw' directly onto the PDF surface with a stylus or finger. This is a useful function that would be better accompanied by variable pen thickness sizes.

C.3.3 Comments

PRS-600

Although you cannot simply add a text box to a page and type directly onto it, there is a tool that allows you to add hidden text and handwriting to both bookmarks and highlights (these are known as comments). Sadly however, this facility is so well hidden within the device that it can take weeks to find via random discovery. This situation is exacerbated by the absence of a full manual with the Reader. To add a comment, a previously created bookmark or highlight must be tapped once (double tapping accesses a different function) to bring up a menu that allows users to choose the type of comment they wish to anchor to the note: either handwriting or keyboard entry (Note: Comment creation can only be accomplished when the Notes menu is off). Once a comment has been made and committed, it will disappear from view and can be accessed by tapping once on the icon adjacent to the bookmark or highlight. Not only does this functionality deny the creation of comments randomly on a page as each one must be anchored to an existing note, but each note (i.e. bookmarks or highlights) can only sustain one comment each.

C.4 Page Turning

PRS-600

Changing pages on the device can be accomplished either by using the dedicated buttons on the device itself, or by making sweeping gestures on the touch screen. To move to the next or previous pages within the document, the screen must be dragged in the appropriate direction with a stylus or finger, and to repeatedly change pages (i.e. flick quickly through document), the screen must be held after the gesture has been made. The default page turning gesture directions have been designed to coincide with the buttons on the device: specifically, gesturing from right to left (<) takes you to the previous page and from left to right (>) takes you to the next page. These directions, however logical, contradict the learned behavior of reading physical books. For example, when reading ahead in a paper book (i.e. going to the next page), one would take the **right** page and flip it to the **left**. Conversely, to go back to a previous page, one would take the **left** page and flip it to the **right**; completely opposite to the gestures provided in the devices hardware.

Fortunately, the page turn gesture can be modified from its default direction via the device settings in the main menu.

C.5 Magnification

PRS-600

The PRS-600 offers two types of document resizing. The first, which allows users to change to one of 5 different font sizes (S, M, L, XL and XXL, where S is the original size), is designed to re-render and display a newly formatted version of an open document page with the desired sized font. This feature however, can be slightly temperamental on certain documents. For example, some tables, specifically those that span the entire width of a two columned document prohibit larger font sizes for that particular page (i.e. M, L, XL and XXL). In addition, some images, particularly embedded PDF images, are rendered incorrectly with the device reformatting any text within them along with the main body of the document. To get around any possible magnification problems, the device also offers a standard zoom function that does not reformat document pages, but zooms in on specific points and facilitates panning using 4 directional arrows on the touch screen.

One major downfall of the device is its lack of consistency of the zoom function. Specifically, one can zoom in on documents but not on menus making the device extremely difficult to use for visually impaired users.

C.6 Usability

PRS-600

Another problem with the PRS-600 software design is that the main options menu unnecessarily spans two pages (i.e. you must click to change to the second half of the menu) despite the fact there is sufficient room on the screen to place all items within it on one page. This adds a needless extra click to an already slow menu system and goes against the minimal refresh/screen clicks principle we laid down earlier.

D. AMAZON KINDLE 2

D.1 Ergonomics

Kindle

There are several notable properties of the ergonomic design of the Amazon Kindle 2. Firstly, it is useful to note that its sleek thin shape and lightweight properties make it easy to hold with one hand. This, coupled with the clever positioning of the two 'Next Page' buttons, makes linear reading easy to accomplish with the thumb of the right or left hand. Unlike the Sony's, the Kindle 2 does not have buttons with icons above them, they use descriptive words on the buttons themselves to state their purpose. The size of the Kindle's buttons are also a lot larger than the Sony Touch, making them much easier to press.

Unfortunately, the thought that went into the design and position of the next buttons was not given to the function of the 5-way directional stick. This mini joystick does not promote direct manipulation [12] as it is hard to control the on-screen cursor using continuous movement on a slow refresh screen speed. An alternative, but tedious and difficult, way of navigating with the 5-way, is to continuously flick up, down, left or right to scroll through on screen menus.

D.2 Bookmarks

Kindle

Following suit with the Sony Touch's design, the Kindle does not have a dedicated button for bookmarking. Instead, to bookmark a page the user must click **Menu (button)** then scroll down 6 items and select **Add a Bookmark (on screen menu)**. To bookmark a page on the Kindle then,

requires 8 button clicks; a rather large number for such a commonly used function. On closer inspection of the user manual, I discovered the Kindle does have an accelerator shortcut for this which makes bookmarking far less cumbersome: **ALT (button) + B (button)**.

When a page has been bookmarked, it renders a 'dog eared' corner in the top right of the screen. Surprisingly however, pages that have not been bookmarked, show a dashed dog ear in the top right corner; a confusing design that has no apparent function whatsoever.

D.3 Annotations

Kindle

Despite the lack of touch screen, the Kindle 2 still offers a small set of mark-up tools. These include highlights and notes and can be viewed in a list (all grouped together with bookmarks too) from the main menu: **Menu (button) – My Notes and Marks (on screen menu)**.

D.3.1 Highlights

Kindle

To create a highlight the user must first be in annotation mode. This is accomplished either by moving the caret into the document area (simply by using the directional stick) or by selecting **Menu (button) – Add a Note or Highlight (on screen menu)**. Next, the user must move the caret to the beginning of the place they wish to highlight using the 5-way directional controller and 'start' by clicking the 5-way down. The caret then turns italic and will highlight text that is selected using the 5-way directional buttons. Clicking the 5-way down again will finish the highlight which is subsequently indicated by a faint grey underline.

D.3.2 Notes

Kindle

Users can add notes to specific points in the text by first going into annotation mode (described above) then moving the cursor to the place in the text they want to anchor the note. To create a note in a specific location, the user only needs to start typing using the full QWERTY keyboard included on the face of the device. They then select the 'save note' option using the 5-way and a new note is created in the specified position.

D.4 Page Turning


Kindle

There are two next buttons but they are positioned in the right place for fingers unlike the Sony reader where you have to strain your hands to use. Has been designed with both right and left handed users in mind. i.e. there are *two* "next" buttons positioned on the sides of the devices in such a way that they can be utilized by either thumb and more importantly, be used with only one hand.

Since books are designed to be read sequentially from start to finish, the previous button is expected to be used less frequently. This is reflected in its position: a single small button above the 'Next Page' button on the left of the device.

D.5 Magnification

Kindle

The Kindle 2 offers 6 font size variations accessible through the size  button on the device. It also allows users to change the margin size of the text using the strangely worded 'Words Per Line' feature of: *fewest, fewer, default*. Following suit with the Sony's inconsistency, the Kindle 2 also sets its menus at a fixed size. Unlike the Sony's however, the Kindle gives no visual, audio or tactile feedback when attempting to change the font size within a menu.